Reclamation

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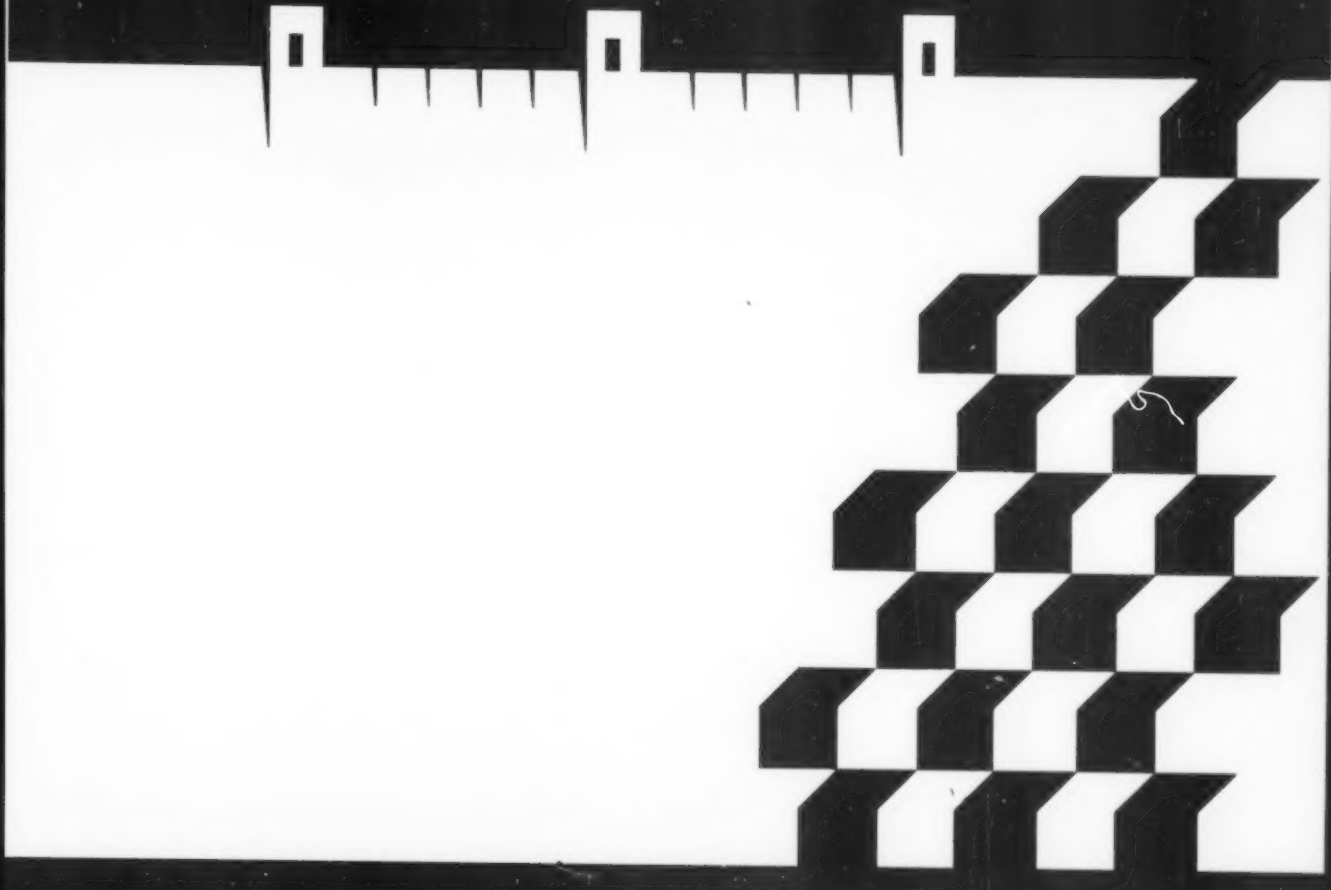

Reclamation

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Spring/Summer 1981

United States
Department of the Interior

James G. Watt, Secretary

Bureau of Reclamation

Robert N. Broadbent
Commissioner

Editor
Carol A. White

Inquiries should be addressed to: Editor, *Reclamation Era*, Bureau of Reclamation, Code D-140, PO Box 25007, Denver Federal Center, Denver, CO 80225

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Table of Contents

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As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under US administration.

The Bureau is The Bureau... Again

"The name Bureau of Reclamation is one of historical significance as well as a symbol of excellence."

On May 20, 1981, Secretary of the Interior James G. Watt announced the restoration of the "historical title." The Water and Power Resources Service again became the Bureau of Reclamation.

The agency was renamed in November 1979, but the new name "Water and Power Resources Service" did not catch on and was poorly received. "The public we serve did not like it. The name proved to be awkward, difficult to use in speech and writing, and lacked a logical and convincing short form."

The title of "Commissioner of Reclamation" was also restored by this Secretarial order.

Although Reclamation is relatively unknown to millions of Americans, the agency has been a highly significant and visible presence throughout the West for almost 80 years. Water from Reclamation multipurpose projects have helped farmers literally make the desert bloom. Produce from Reclamation irrigated areas provide fresh fruits and vegetables for the Nation year round.

Over the years, Reclamation benefits have broadened far beyond its original mission to include hydroelectric power, municipal and industrial water, wind and solar power research, fish and wildlife enhancement, outdoor recreation, flood control and atmospheric water (cloud-seeding) research.

The Bureau of Reclamation is world renowned for its engineering expertise. Engineers from foreign countries come to the Bureau of Reclamation for advanced technical training and then return to their countries to implement what they have learned. Reclamation engineers are sent to foreign countries on short assignments as well as temporary tours of duty. They act as consultants in such countries as Brazil, Zaire, Thailand and Saudia Arabia, to name a few.

The Bureau of Reclamation headquarters office is located in Washington, D.C. Regional offices are in Boise, Idaho; Sacramento, California; Salt Lake City, Utah; Boulder City, Nevada; Billings, Montana; Amarillo, Texas; Denver, Colorado.

Introducing... Commissioner of Reclamation Robert N. Broadbent

Interviewed by Linda Amato Bard
April 1981, Denver, Colorado

When asked how he felt about heading an agency composed primarily of engineers and scientists, Commissioner Robert N. Broadbent candidly replied, "Overwhelmed!"

Broadbent, an energetic, down-to-earth politician and former pharmacist from Boulder City, Nevada, went on to say he intends to rely heavily on the engineering and technical people who make up the Bureau of Reclamation.

Broadbent has been active in Nevada politics for a number of years.

Linda Amato Bard is a Writer-Editor in the Public Affairs Center, Denver, Colorado.

Photography by John R. Norquist, Engineering and Research Center, Denver, Colorado.

He was a member of the Boulder City City Council, and had been a member of the Clark County Board of Commissioners from 1968 until his Washington appointment. As Boulder City's first mayor, Broadbent was instrumental in negotiating the change in status from a federally-owned and -operated town to a Nevada municipality. (See *Era* article in this issue, "The Town That Built The Dam")

Broadbent was also a director of the Las Vegas Valley Water District, a trustee of the Clark County Sanitation District, a member of the Regional Planning Council, the Clark County Health District and the Regional Streets and Highways Board.

Though engineering is the name of the game for Reclamation, politics will still be the arena for this Nevada statesman. "I intend to be very active politically," Broadbent said. "That's where your programs are won or lost. Whether we like it or not, you can be the best professional organization in the world but if you can't carry your message to the right people, you don't get what you need."

"I intend to be very active politically," Broadbent said. "That's where your programs are won or lost..."

"I view my appointment as Commissioner of the Bureau of Reclamation as a real challenge. I intend to serve the Administration in the best and most honest way I know how, and to follow the policy that has been set down by the Administration," he said.

In his role as Commissioner, Broadbent is taking "a tiger by the tail" as he picks up the reins of a government agency which has enjoyed a reputation of excellence, but has also known reorganization, controversy and criticism. However, Robert N. Broadbent is an optimistic man. "I think the future of the Bureau of Reclamation is really bright," he said. "Once we get over the economic hurdles, we will see a rapidly expanding agency trying to solve the water and power problems as we develop our resources in the West," he added.

Although Reclamation has absorbed a budget reduction, Commissioner Broadbent said he sees Reclamation as a viable, growing agency. "The Bureau operates and maintains water and power facilities and irrigation projects that are needed for the benefit of this country. And, in time, when the economy allows it, we will have an expanded construction program," he said.

Broadbent is concerned that the Bureau of Reclamation find a balance between the environmental aspects of dam building and what this country needs for growth and development. "If there is a conflict between an environmental concern that has limited consequences and our resources, our economy, our growth and our welfare, my choice is going to be with the people," Broadbent said. "That doesn't mean we shouldn't be concerned about our environment, but somewhere along the line you have got to make a judgment decision... what comes first?"

"I think the future of the Bureau of Reclamation is really bright."

Broadbent is married and has four children. He and his wife, Sue, and 12-year-old Betty Michelle are making their home in Springfield, Virginia. Another daughter, Kathleen Morris, is an accountant in Boulder City. Broadbent has two sons: Robert is a hydrogeologist for Phillips 66 in Salt Lake City; Douglas is attending Brigham Young University in Utah.

Reflecting on the busy schedule he will be keeping for the next four years, Broadbent added, "When the kids were growing up, we spent a lot of time boating and skiing on Lake Mead. We have a cabin in southern Utah where we like to go in the winter, too. I guess that's out for a while."

BOULDER
CITY

Nevada Highway in Boulder City, taken from the Administration Building (1932).

The Town... That Built... The Dam

By William J. (Bill) Williams

The news had spread rapidly. It was 1930, and "Uncle Sam" was getting ready to build the world's highest concrete dam in the Black Canyon of the Colorado River, between Nevada and Arizona.

Men by the thousands beat a path to the construction site in the southern Nevada desert. All wanted to be a part of the challenge of building the greatest engineering project of the time.

William J. (Bill) Williams began his Reclamation career in December 1945 when he arrived in Boulder City from the Department of Agriculture in Washington, D.C. He remained the Public Information Officer for the Lower Colorado Region until his retirement in 1980, 35 years later. Williams is still a resident of Boulder City.

Current photography by Irene Whalen and Bill Harbour, *Boulder City News*, Gene Hertzog, Lower Colorado Region; historical photographs by R. C. Middleton, G. A. Beyer, J. Madrigal, O. G. Patch, Lower Colorado Region.

What they found was a hostile wilderness of sand and cacti, tumbleweeds, and cresote bushes, coyotes and rattlesnakes ... where the sun beat down mercilessly during the long, hot summers. Only prehistoric man, early Spanish and American explorers and Mormon missionaries had left footprints along the Colorado and in the surrounding hills.

Later, the engineers from the Department of the Interior's Bureau of Reclamation came to survey the dam and the town sites. The first arrivals lived in tents and shacks until dormitories for the singles and houses for the marrieds could be built. Some even slept on the courthouse lawn in Las Vegas near the hiring hall, hoping to get jobs at the damsite. It was rough going ... the hardships were great.

Ask Joe and Mildred Kine, two of the first "31'ers." They were among the first to arrive in Boulder City in 1931. But, despite the hardships, the Kines were happy because Joe had a job. He was one of the brave men called "highscalers," who swung from ropes at dizzying heights, drilling dynamite holes in the canyon walls and prying away loose rock after each blast.

Las Vegas was the closest community to the damsite. But Las Vegas was 30 miles away, too far to serve as a construction camp.

One of Six Companies' residences built for employees (1932).

"Red" and Catherine Wixson greeting their neighbors and fellow Boulder City citizens during the 50th anniversary parade honoring Boulder City's beginning in 1931.

Boulder City construction (1930).

Reclamation had to find a site closer to the construction.

The Commissioner of Reclamation, Dr. Elwood Mead, personally selected the townsite after hiking among the hills overlooking the Colorado River. It was seven miles southwest of the damsite and nearly 2,000 feet in elevation higher than the riverbed. The new townsite averaged 10°F. cooler than other sites located along the river. This was important. After enduring the summer daytime temperatures of up to 125°F. in Black Canyon, workers looked forward to getting back on the hill to "cool off" at home, according to "31'er" Leo Dunbar, Sr.

Commissioner Mead called upon architect S. R. DeBoer to lay out the proposed town. And from DeBoer's drawing board emerged a fan-shaped city with its apex atop a hill on the north with a view of the future reservoir. On this hill Reclamation built a large Spanish-style office building for Construction Engineer Walker R. Young and his staff. Today, it is headquarters for the Lower Colorado Region.

Authorized by Congress in 1923, the Boulder Canyon Project funds provided for a town as well as the dam. In 1930 the Secretary of the Interior named Hoover Dam for President Herbert Hoover, who signed the first appropriation bill to get the project underway. Later, the names Boulder Canyon Dam and Boulder Dam were used. However, in April 1947, the name Hoover Dam was restored by congressional action.

On March 11, 1931, the contract was awarded for the construction of Hoover Dam. The dam construction was awarded to Six Companies, Inc., a group of six successful western contractors: Utah Construction Company, Pacific Bridge Company, Henry J. Kaiser and W. A. Bechtel Company, MacDonald and Kahn Com-

pany, Ltd., Morrison-Knudsen Company and J. F. Shea Company.

The "Big Six" selected Frank T. Crowe to work with Reclamation's construction engineer. Crowe was already a noted western dam-builder, after working on Jackson Lake Dam in Wyoming, Tieton Dam in Washington State, Arrowrock Dam in Idaho and Flathead Dam in Montana.

Crowe and Young would achieve fame by building the then world's greatest multipurpose water project. Hoover Dam was named by the American Society of Civil Engineers in 1955 as one of the Nation's Seven Modern Civil Engineering Wonders.

On March 16, 1931, only five days after the dam contract was awarded, construction was begun on Boulder City, the town. Work progressed simultaneously on Boulder City and Hoover Dam. The Union Pacific Railroad first built a spur to the town from its main line through Las Vegas. Six Companies extended the line to the canyon rim at the damsite. Meanwhile, workers were building a pumping plant on the river below the damsite and a pipeline up the hill to a filter plant in the townsite. And to go along with this system, water and sewer lines were being laid throughout the townsite. While waiting for delivery of river water through the new system, water was hauled to the townsite in railroad tank cars.

Boulder City (1932).

Boulder City (1977).

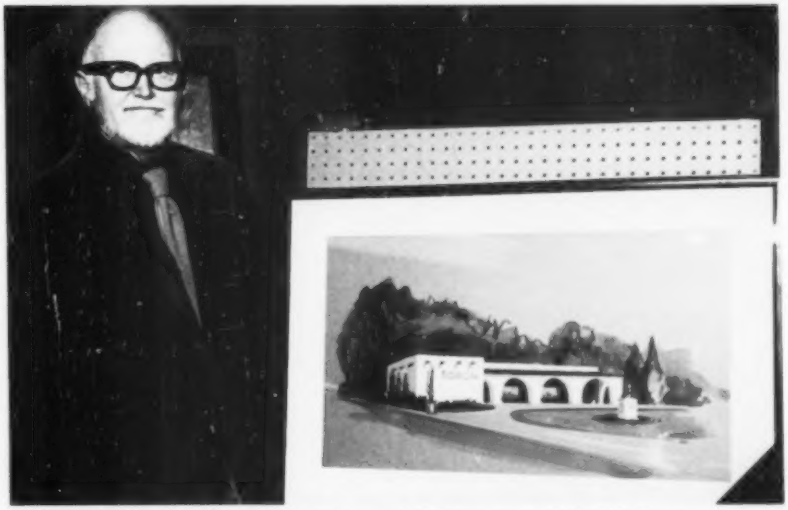
The "31'ers" annual luncheon was a highlight of the 50th anniversary celebration.

Boulder City's train station (1931).

Houses and dormitories for Six Companies' and Reclamation employees appeared to rise from the desert overnight. Power lines to serve the residents with electricity brought from southern California were strung. Schools and churches sprang up. A small group of businessmen established stores and operated them under Federal permits. One of these modern-day pioneers was Earl Brothers, who built a theater and visitors bureau. He is credited with putting together the original Hoover Dam construction movie footage filmed by newsreel, Six Companies and Reclamation photographers.

Another "31'er," Hobert Blair, planted many of the trees and lawns that beautify Boulder City. He recalls how difficult it was to keep the young trees and grass alive because of the extreme summer heat and drifting sand. Fortunately, the trees and grass won the battle, and Boulder City became a beautiful green oasis in the Great American Desert.

Reclamation planned the town for about 6,000 residents during the construction period, and for 1,500 residents needed for operation and maintenance of the dam and powerplant after completion. Only those with jobs on the project and their families, were permitted to live within the Federal reservation encompassing the town and damsite.



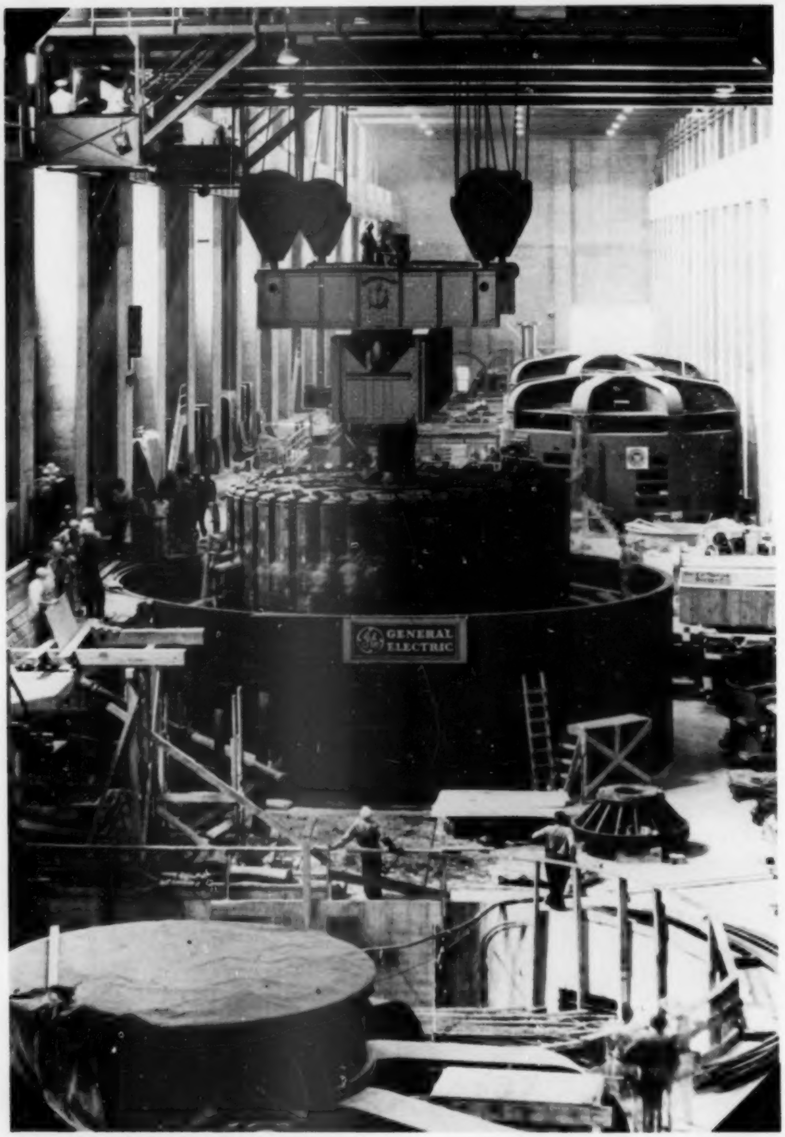
Cliff Segerblom displays his architectural concept of the museum to be built in Crowe Memorial Park.

Sims Ely, father of noted western water lawyer Northcutt Ely, was hired to run the town for the Federal Government. Oldtimers remember Ely as a benevolent dictator—well-liked but firm.

Boulder City in the 1930's was probably the Nation's busiest little town. Working around the clock in three 8-hour shifts, men shuttled to and from the Black Canyon damsite in multidecked buses. The crews were some of the most efficient ever assembled in one place. They completed the job in five years, two years ahead of schedule. However, everything has its price—96 men paid with their lives while working on this engineering marvel.

The feat of building the world's highest dam and creating the largest reservoir of that time was noted throughout the world. In dedicating Hoover Dam on September 30, 1935, President Franklin D. Roosevelt declared: "This is an engineering victory of the first order—another great achievement of American resourcefulness, skill and determination."

As construction sounds faded into history, the contractors and some of the workers moved on to other jobs. Boulder City's population shrunk to less than 3,000. Most of those remaining were employees of the Bureau of Reclamation, the Los Angeles Department of Water and Power, and Southern Califor-



Hoover Dam's first generating unit was installed in 1936 and went into production later that year. It was located in the Nevada wing of the powerplant.

nia Edison Company, who were needed to operate and maintain the dam and powerplant. Later, National Park Service personnel arrived to oversee the Lake Mead National Recreation Area. The Bureau of Mines brought in scientists to establish and operate a metallurgical laboratory. Boulder City was truly a Federal city.

With the economic depression over and the Nation in the midst of World War II, "the town that built the dam" started on a come-back trail. The Pacific Southwest was receiving more than half of its electrical energy from Hoover Dam and needed more. So, Reclamation expanded Hoover's powerplant to accommodate more generating units.

Wartime activity brought more people to Boulder City with the establishment of Nellis Air Force Base near Las Vegas, and the Basic Magnesium Plant at Henderson. In addition, the mild winter climate and the recreation possibilities nearby brought retirees and tourists flocking to southern Nevada and Boulder City.

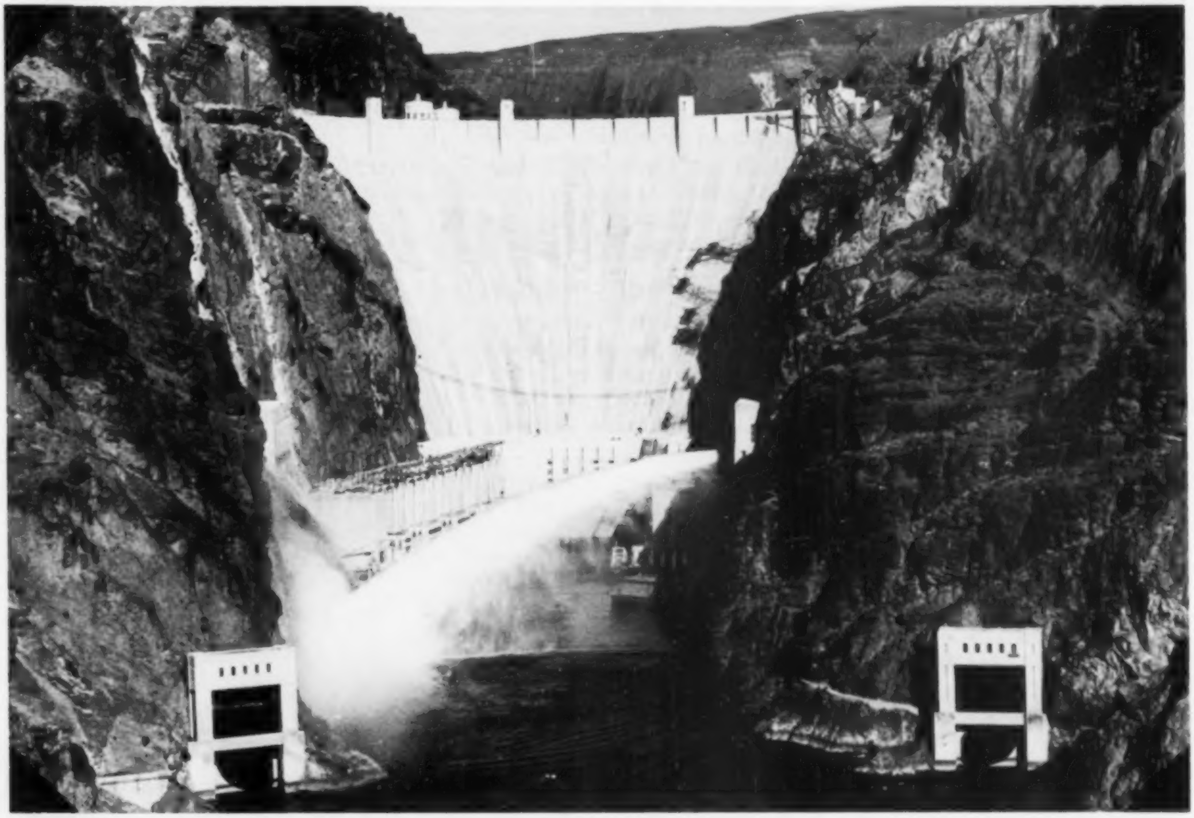
Boulder City flourished, but Federal authorities knew the umbilical cord had to be cut. In 1951, the Secretary of the Interior ordered that steps be taken to separate the town from the Boulder Canyon Project and to help the town to incorporate under the laws of Nevada. As a result of a Federally sponsored study by Dr. Henry J. Reining, Dean of the University of Southern California's School of Public Administration, the Congress passed the Boulder City Act of 1958. This legislation permitted the Bureau of Reclamation to help Boulder City incorporate under Nevada law.

Elton Garrett, the town's first high-school principal and newspaper reporter, along with Robert Carter and Morry Zenoff, editors of the *Boulder City News*, led the incorporation movement. In a special referendum vote, the town's citizens overwhelmingly approved self-government. It became effec-

tive in October 1959. And, on January 4, 1960, Reclamation's Regional Director A. B. West, acting for the Secretary of the Interior, turned over Boulder City to the incorporated citizenry. A banner headline on the front page of the *Boulder City News* proclaimed: "The Birth of a City."

After 29 years of Federal management, the Bureau of Reclamation transferred to the citizens of Boulder City some 33 square miles of land plus electrical, water and sewer systems, buildings, streets, sidewalks, parks, other property and equipment.

The current Commissioner of Reclamation, Robert N. Broadbent, was a member of the first City Council and Boulder City's first mayor. He also served on the charter commission that prepared the community and its citizens for self-government.



Hoover Dam.

The key to Boulder City rests in the hands of the past and present: (from left to right) Boulder City Mayor Bob Ferarro; former Regional Director A. B. West; present Regional Director Eugene Hinds; Commissioner of Reclamation Robert N. Broadbent, first mayor of Boulder City.

Today, Boulder City claims the distinction of being the Nation's only community to have observed two important anniversaries this year. On January 4 the town celebrated its 21st anniversary as a self-governed incorporated municipality, and on March 16 the town celebrated its 50th anniversary of Boulder City's beginning.

Boulder City marked the 21st anniversary of the town's incorporation by reenacting—in the old school gymnasium—the ceremony transferring the reins from the Federal Government to the citizens. Among the original participants who were on hand to celebrate and take part in the reenactment were Commissioner Broadbent—who as mayor of Boulder City at the time of incorporation received the reins from the Federal Government— former Regional Director of the Lower Colorado Region, A. B. West, who transferred the town from Federal Government management to the citizens and former Governor of Nevada Grant Sawyer. Both Broadbent and West noted that Boulder City had prospered under self-government.

Later, on March 16, Boulder City's residents lined Nevada Highway to cheer a parade of marching bands and "31'ers" riding in antique cars. The parade ended at the new Frank T. Crowe Memorial Park at the corner of Nevada Highway and Cherry Street. There, a bust of the famous dam-builder was unveiled by S. L. "Red" Wixson, who was Crowe's righthand man during Hoover's construction, and Wixson's wife, Catherine. The park and the sculpture were donated to the town by the Wixsons.

A museum housing Hoover Dam and Boulder City memorabilia is planned for the Crowe Memorial Park. The museum is a major project of the Boulder City Museum and Historical Association, organized in 1980. The group boasts over 500 charter members as well as a substantial number of annual memberships. The association already is planning a big celebration on May 29, 1985, the 50th anniversary of Hoover Dam's completion.

The architectural concept of the new museum was done by noted western artist Cliff Segerblom. Segerblom, a pioneer resident of Boulder City, photographed Hoover Dam in the early days for the Bureau of Reclamation. He still uses the dam, Lake Mead and other desert scenes around Boulder City as subjects for his canvases and photographs.

Residents of Boulder City see the future of the town as a continuation of "the good life." Two years ago the citizens voted to limit new building within the city limits. The residents want to maintain and preserve the uniqueness of Boulder City as a small town. Too much growth would exhaust the town's present resources, especially the water and electricity. And, the town would lose its reputation as "clean, green Boulder City."

The town derives some revenue from the many thousands of tourists and recreationists who visit Hoover Dam and the Lake Mead National Recreation Area every year. Other attractions include an open-air art festival held in October, the American Legion's "Damboree" held every Fourth of July and the Horsemen's Association sponsors a rodeo every spring.

A handful of small, non-polluting industries and research units operate within the city limits. The University of Nevada Desert Research Institute's Energy Systems Laboratory, which is heated and cooled by solar power, is working on more efficient ways to use solar power. Boulder City is a prime location for this type of research because the sun shines almost every day of the year. You can bet on this . . . the local tavern does. The pub gives free beer every day the sun doesn't shine. They don't give away much beer.

Every year, fewer and fewer "31'ers" show up at the annual luncheon in April. Someday there will be none. But, they will always be remembered by the citizens of "the town that built the dam."

Left to right: Patty Crowe Lee, Catherine Wixson stand with Betty Crowe Parry and "Red" Wixson, at the bust of Frank Crowe in Memorial Park, March 14, 1981.

Entrance to Boulder Canyon Project Federal Reservation (1932).

Let's Pretend...

The Wasatch Aqueduct, Roman Style

By Roger Hansen

Let's pretend that the design of the Wasatch Aqueduct, one of the key elements of the Central Utah Project, will be done by Imperial Roman engineers in the year 82 A. D., instead of being sent to Reclamation's Engineering and Research Center in Denver in 1982, nineteen centuries later.

The Wasatch Aqueduct is an essential feature of the Bonneville Unit. It is a critical link in a water conveyance system which will transport 100,000 acre-feet of water from Utah's Uinta Mountains of the Wasatch Range, to farms and towns in the Great Basin. The Wasatch Aqueduct is the name given to that segment of the system which crosses southern Utah County, from Strawberry Reservoir southwest to Sevier Bridge Reservoir.

An aqueduct is a water conveyance system consisting of pipelines, tunnels and siphons. Roman engineers were hardly novices at designing such systems. During the first century Imperial Rome was served by nine aqueducts, bringing fresh water from the surrounding green hills. Romans had a great mistrust of water from the Tiber River which flows through the city.

The Roman aqueducts, much like the Wasatch Aqueduct and many other modern water systems, consisted of tunnels, channels elevated on arched bridges and inverted siphons. The lengths of these ancient aqueducts varied from 12 to 50 miles. In all, Rome was served by over 300 miles of water systems. Vestiges of the ancient Roman aqueducts are still very much in evidence in and around modern Rome.

The ancient aqueducts were documented in great detail in the writings of Sextus Julius Frontinus, Imperial Rome's water commissioner at the close of the first century.

Frontinus' books have made him the most famous of the Roman engineers. He wrote *De Aguis Urbis Romae,* his personal account of the Roman water system. He described in proud and minute detail, the sources, length and function of each of the city's aqueducts and concluded: "... with such an array of indispensable structures carrying so many waters, compare if you will, the idle pyramids or the useless, though famous, works of the Greeks."

He considered functionality the ultimate test for evaluating the worth of a project. For seven years prior to his death, Frontinus struggled to bring order and efficiency to the operation of a utility which had been previously mismanaged. There could not be a better historic figure to supervise the design work on the Wasatch Aqueduct.

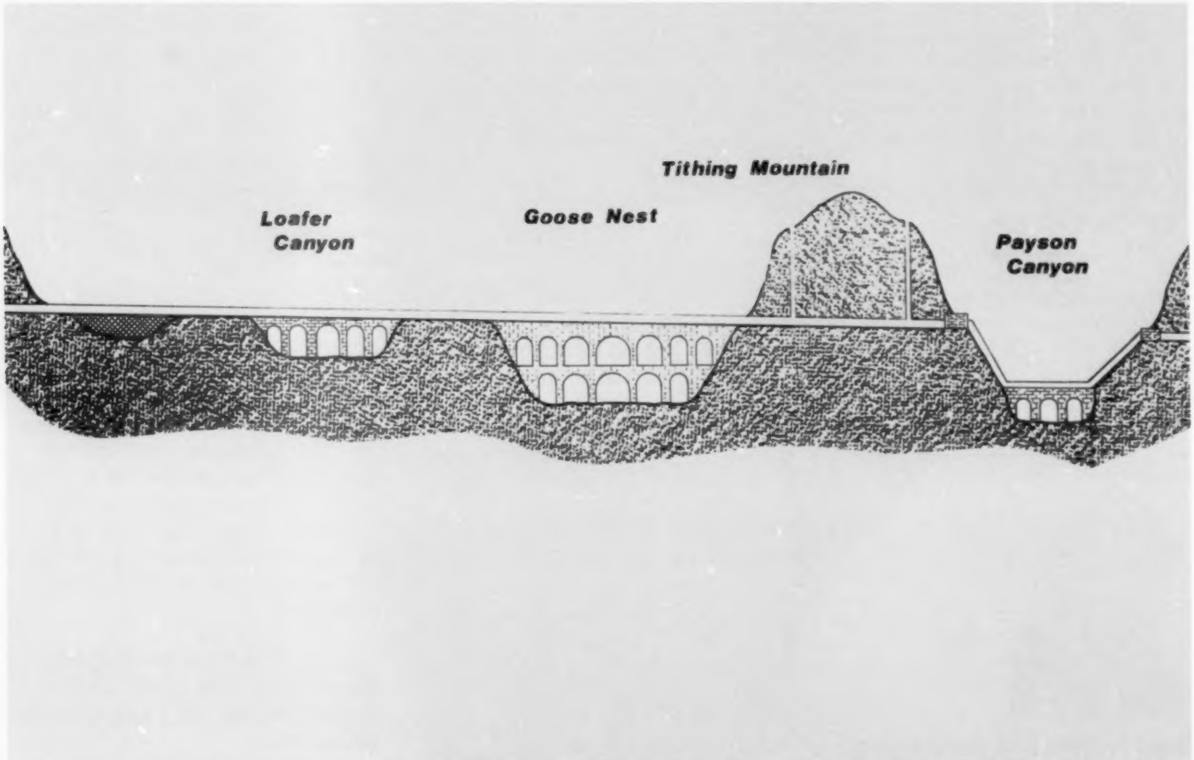
Imagine Frontinus bending over his drafting table in his office in Imperial Rome. Let's look over his shoulder.

The reach he is working on extends from a tunnel outlet portal on the Wasatch Front to a tunnel inlet portal in nearby Payson Canyon. The total distance crossed by this reach is five miles.

After leaving the tunnel outlet portal, the aqueduct would transport water in a gently downward sloping channel. On reaching a shallow depression the channel would be supported on an earth

Roger Hansen is a civil engineer in the Utah Projects Office, Provo, Utah. He is the team leader for irrigation and drainage on the Bonneville Unit; Wasatch Aqueduct is a part of the irrigation and drainage system.

Photography by Tom Fridmann, Utah Projects Office. Graphics by Floyd Barnes, Utah Projects Office. Historical photographs of Roman aqueducts were taken from the book, *The Aqueducts of Ancient Rome,* Oxford at the Clarendon Press, 1935.



A segment of the Wasatch Aqueduct as it might have been designed by Frontinus and built by Imperial Roman engineers. With the water flowing from left to right: on reaching a shallow canyon, the aqueduct is carried on an earth embankment; in a deeper canyon, the water is carried on an arched masonry bridge; a two-tier bridge is used to cross a deep ground depression; note the vertical cleaning shafts as the aqueduct goes underground; at a canyon inverted siphon carries water down one side, across a low arched bridge and is pushed by water pressure up the other side.

embankment. A short arched bridge would be required to cross Loafer Canyon. The covered channel would continue to the southwest at ground level until it reached the Goose Nest area.

Across the Goose Nest, the Roman Wasatch Aqueduct would be elevated on a majestic two-tier bridge. This long arcade would be highly visible and create an elegant tourist and recreation attraction in southern Utah County, rivaling Havasu City's London Bridge in Arizona.

Once across the Goose Nest, water would flow in a tunnel through Tithing Mountain. This short tunnel would be equipped with vertical shafts. These shafts would facilitate inspections and cleaning. (Author's note: Roman tunnels were cleaned by slaves. The collected debris was dumped beside the vertical shaft. Modern archeologists have been able to find and trace these ancient conduits by identifying the piles of stone, gravel, silt and calcium-type deposits.)

After leaving the tunnel, an inverted siphon would carry water across Payson Canyon. The siphon, built of lead pipes laid side-by-side, would extend from a distributing tank (called a header tank) down one side of the canyon, across a low arched bridge, and up the other side to a receiving tank. The pipes for the siphon would be very heavy, requiring hundreds of tons of lead.

After crossing Payson Canyon, water would flow into another tunnel on its way to Sevier Bridge Reservoir.

In all, only ten percent of the distance of the illustrated reach would be elevated on arches or bridges. The popular conception of Roman aqueducts is that they were elevated throughout their entire length on magnificent arcades. Such a picture, though, is inaccurate. Roman engineers were exceedingly practical. The routes their water conveyance systems followed were, where possible, on a downward gradient at or near ground level. In the system serving Imperial Rome, only five percent of the distance was elevated on arched bridges.

Anio Novus was a rock-hewn underground channel built around 269 B.C. According to Frontinus, it was built underground for tactical reasons.

Many Roman aqueducts were built before Christ and are still visible today.

From an operation and maintenance point of view, the Roman arched bridges were not an unqualified success. Both written and archeological records indicate there was a need for extensive and frequent repairs. For example, one aqueduct was under construction for fifteen years. It was repaired after being used for only ten years and left idle for nine years. After returning to use, it was repaired again nine years later and worked on again four years later. Evidence of substandard construction and repair work is obvious on sections of the aqueducts which still stand.

The Romans also had persistent problems with individuals tapping into their aqueducts. Frontinus describes the problem: "... a large number of landed proprietors, past

The Goose Nest area today. The Wasatch Aqueduct will be buried pipeline through this area.

An artist's conception of what the Goose Nest two-tier bridge might look like.

whose fields the aqueducts run, tap the conduits; whence it comes that public water courses are actually brought to a stand still by private citizens, just to water their gardens." The Roman engineers' inability to stop illegal connections was, in part, tied to the fact that they could not calculate either theoretical or actual flow.

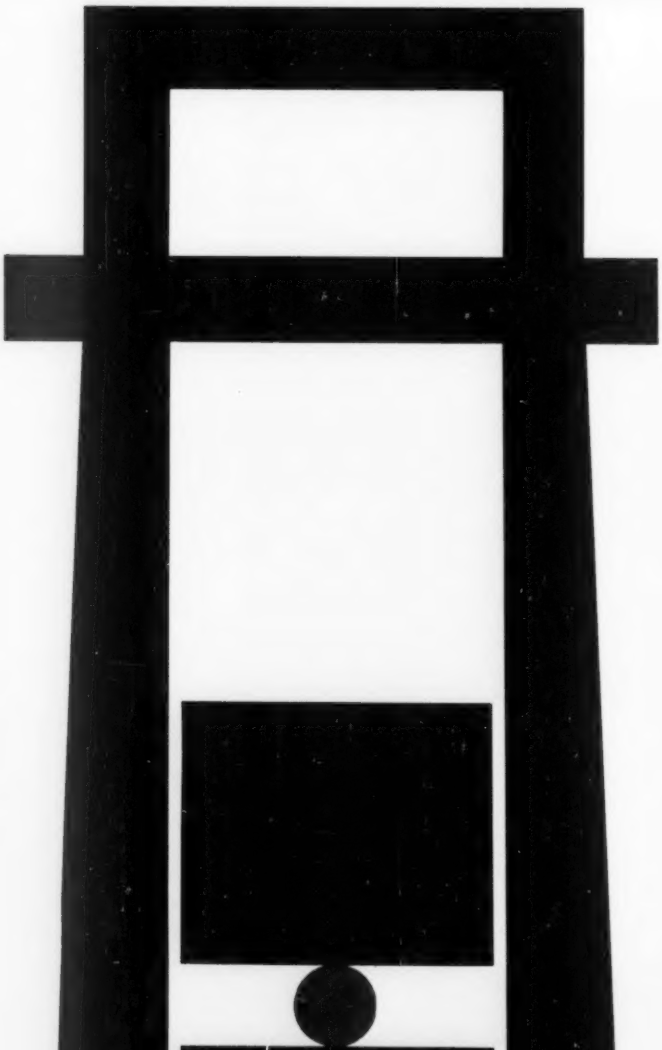
Returning to the Twentieth Century, today's design for the Wasatch Aqueduct is considerably less dramatic. Except for the tunnel segments, the aqueduct will be a buried pipeline. The concrete pipe will be approximately six feet in diameter and require almost no maintenance compared to its Roman counterpart. Buried pipeline needs only a periodic check for leaks and, every six years, a complete internal inspection. Buried pipe is also relatively safe from illegal connections.

Frontinus would also have had a problem containing the Wasatch Aqueduct's maximum flow of 200 cubic feet per second. He did not understand that flow in an open channel is a function of velocity which is dependent on slope. The slopes of the Roman aqueducts were more closely related to topographical conditions than hydraulic considerations. The construction of a Roman aqueduct was trial-and-error process. A section of the aqueduct was built first. If the resulting flow was too small for their liking, the Romans would either increase the slope or increase the area.

Today, Bureau of Reclamation engineers have precise methods for computing flow. The continuity equation (flow equals area times velocity) correctly determines the maximum flow. The slope and location of open channels are not determined by trial-and-error, but by hydraulic and geologic considerations.

While the knowledge of hydraulics was primitive and the understanding of velocity was unknown, Rome's water system was remarkably functional. It transported an unusually large quantity of water from distant streams and springs into the city. Imperial Rome's water system stands today as one of the great engineering achievements of history.

Major segments of the aqueduct, as it is now envisioned, will be 6-foot concrete pipe, buried.



Fifty Years Of Concrete Research

By Marlene Johnson

"I didn't know there was so much to know about concrete. I thought it was all the same."

Perhaps this statement summarizes the sentiments of many of the high school students who took part in a recent Concrete and Structural Branch career day.

The year of 1981 marks the 50th Anniversary of the Bureau of Reclamation's Concrete Laboratory at the Engineering and Research Center in Denver. As part of the celebration activities, efforts are being made to let others know of Reclamation's significant achievements in concrete research during the last half century.

Concrete was one of man's earliest construction materials. For example, a form of concrete was used in the ancient Roman aqueducts well before the time of Christ. However, little advancement was made in concrete technology until the early 1920's. With the proposed construction of Hoover Dam, a structure that would contain enough concrete to pave a two-lane highway from New York to San Francisco, came the need for new information on the behavior of mass concrete.

The Concrete Laboratory was established in 1931 to meet these new challenges. One of the first results was the development of a low-heat cement which helped make the construction of Hoover Dam possible.

The past 50 years have presented numerous challenges to the concrete construction industry and to the Bureau of Reclamation. The Bureau has met a number of challenges successfully and created its niche in the world of concrete technology.

The 1940's saw the completion of more water resource projects. As additional structures were completed, new problems with concrete surfaced. One problem that became evident was the phenomenon of alkali-aggregate reaction. This is a chemical reaction involving the cement and certain aggregates in the concrete causing expansion and harmful cracking. Research by the Concrete Laboratory and private industry developed low-alkali cements which reduced the expansion and cracking. These specifications are still used today.

Unique to certain geographic areas is the problem of concrete deterioration caused by repeated freezing and thawing. Cooperating with other laboratories, the Concrete Lab researched the entrainment of microscopic air bubbles in concrete mixes. The use of these air-entraining admixtures resulted in a concrete more resistant to the destructive forces of the freeze-thaw attack.

Also during the 1940's, the Concrete Laboratory was researching the replacement of cement with pozzolans, such as fly ash, pumicite or calcined kaolin clay, to further reduce the heat generated in the concrete mass. This research advanced concrete technology by creating a mix that was not only less expensive but also more workable, ultimately stronger and one which generates considerably less heat during concrete hardening.

In the 1960's water-reducing admixtures were introduced. Because the amount of cement

Marlene Johnson is an editoral assistant in the Concrete and Structural Branch, Division of Research, at the Engineering and Research Center in Denver, Colorado.

Photography by Robert Pauline, Photographic Coordinator, Public Affairs Center, Denver, and John Norquist and Wayne Lambert, Engineering and Research Center, Denver, Colorado.

required is directly proportional to the amount of water used for a given strength of concrete, use of these admixtures can save as much as 10 percent cement. Less water also generally means a better quality concrete as was evidenced by data from concrete cores drilled at Glen Canyon Dam where large volumes of concrete with and without water-reducing admixtures were used. Total concrete volume at Glen Canyon was almost 5 million cubic yards. Approximately $900,000 in savings was realized through the use of water-reducing admixtures. At today's cement prices, this savings would amount to about $7 million.

Special consistency tests, such as the Vebe test, are used to evaluate roller-compacted concrete.

Even after 50 years, the Concrete Laboratory continues to be a leader in concrete technology advancement.

New research is now underway on the use of portland cement substitutes which ultimately may reduce the amount of energy needed for cement production. Chemical admixtures called superplasticizers are also being studied as a means to obtain greater workability without additional water. Roller-compacted concrete may contain large quantities of pozzolan, and is placed with earth-moving equipment and rolled in place with vibratory rollers. This technique is an advancement being studied that will make possible more rapid and continuous placement resulting in more economical construction costs.

Research continues in the use of polymer concrete. Substituting a polymer system for portland cement produces a material four times stronger and as much as ten times more durable than conventional concrete. Areas requiring exceptional strength or durability, or situations where repair or maintenance are impractical, are particular targets for use of polymer concrete.

Challenge did not always come in the form of developing new technologies or products, however. The quality control testing of concrete ingredients is an essential function of the laboratory. The Concrete Lab was and remains today a major testing facility. Many other Government agencies and private industry rely on the Bureau for guidance in preparation of standards and specifications.

One of the major contributions of the Lab has been the *Concrete Manual*. Although published primarily for Reclamation field personnel use, the manual has become the "Bible" of the concrete construction world. The first edition was published in 1936 and was 4 by 7 inches in size and one-half-inch thick. Eight editions later, the anniversary issue is 6½ by 9½ inches in size, and 1½ inches thick. A review of the eight editions of the *Concrete Manual* provides a documentation of the evolution of concrete technology in the United States.

The Concrete Laboratory's role has been so significant that particular commemoration is warranted. Planned activities of the 50-year celebration include more career days for local high schools hosted by Concrete Lab engineers and technicians, a face-lift for the laboratory, preparation of a historical booklet, and photo exhibits highlighting laboratory personnel and work activities.

A laboratory technician determines the density of cement for proper mix proportioning.

Trial concrete mixes are made in the lab to help determine the mix design required for each project.

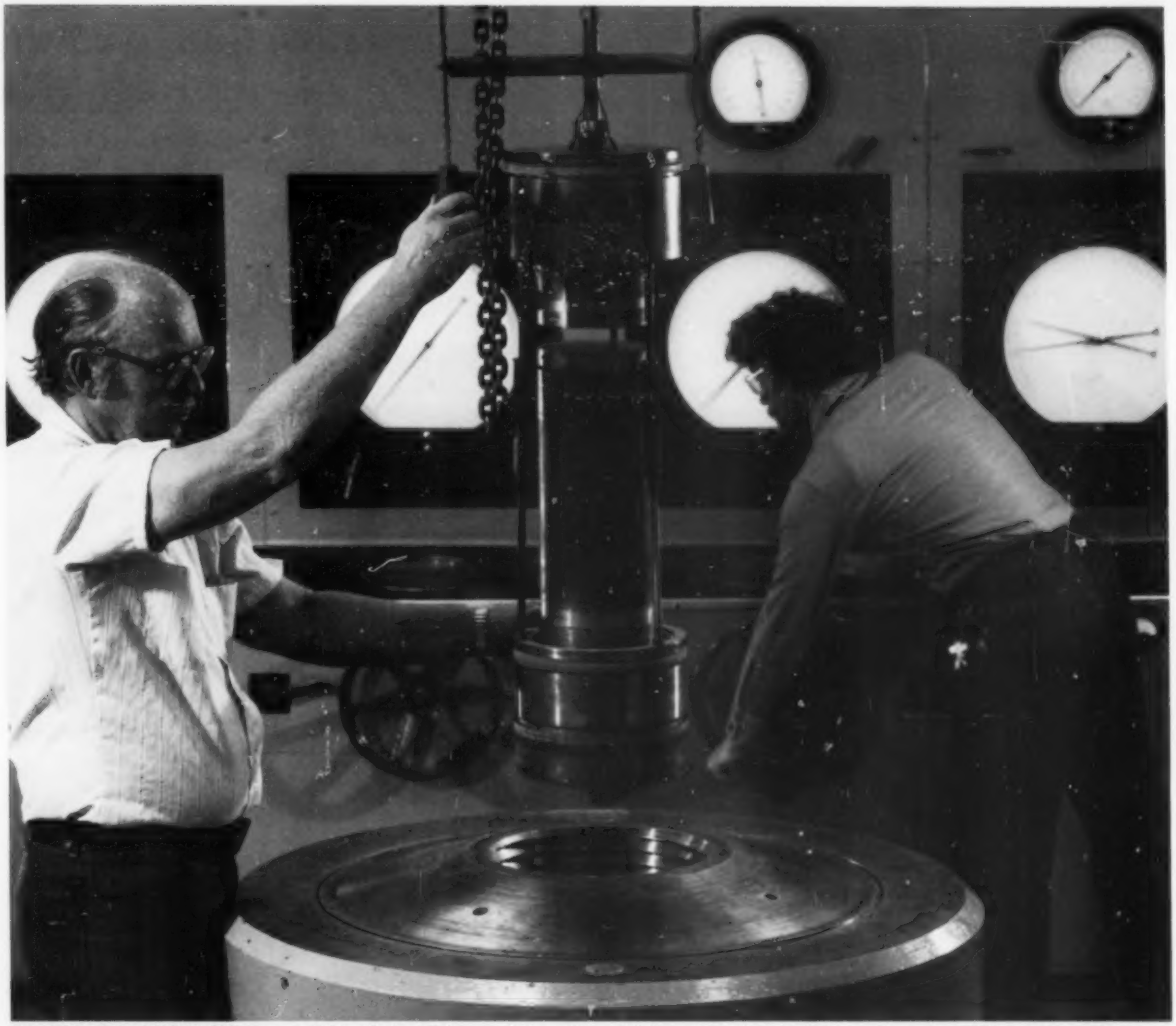
The year's celebration will culminate in December. Beginning the evening of December 2, the Concrete Laboratory will host a banquet with theme "A Time To Recall." Retired employees have been invited to reminisce about the early days and their experiences in the Concrete Laboratory. The next day, December 3, a technical seminar for Reclamation concrete specialists and representatives from private industry will feature presentations focusing on the challenge of concrete technology in the future. Later in the day, the Bureau of Reclamation's Division of Research will host an open house. This event will feature exhibits, slide shows and tours of the laboratory facilities.

For more information on the December events, contact Bureau of Reclamation, Attention: Carl Selander, Code D-1512, PO Box 25007, Denver Federal Center, Denver, Colorado 80225, telephone (303) 234-2774; or Marlene Johnson, Code D-1510, telephone (303) 234-3531.

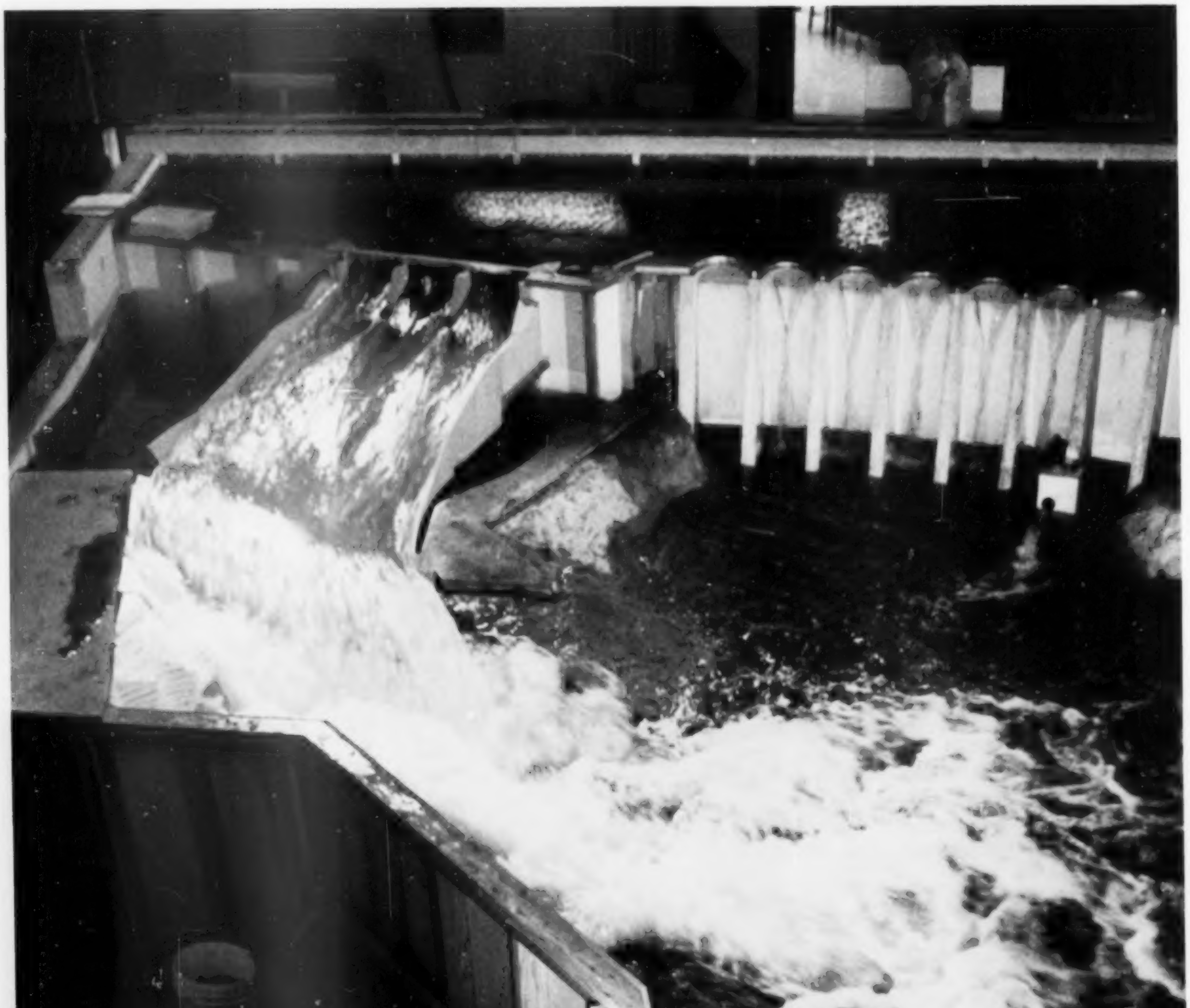
Large concrete cores are prepared for testing by first sawing the ends with a diamond embedded saw blade.

Owen Olsen, a Reclamation concrete lab retiree, described the beginning like this: "I reported for duty and assignment to the Concrete Lab on 18 June 1931. I was one of the first and, I believe, I am the only remaining member of that nucleus organization. Art Ruettgers and Bob Blanks were there at that time, and N. R. Laden. My first job with Laden was to . . . set up an office for the newly established Concrete Lab (at the New Customs House in downtown Denver). Laden and I did not know which one of us was in charge, we took opposite sides of a double desk and considered ourselves as having equal rank. A few days later, E. N. Vidal reported for duty and he took charge. "That was the first real beginning of the Concrete Lab. Another office was later set up in a rented garage on Welton Street. It was known as Welton Street or the Cement Lab. Harmon Meissner was in charge of that facility."

A concrete cylinder is being readied for testing by the 22 200 kN (five million pounds) testing machine in the lab. This test will be done during the 50th Anniversary Open House, December 3, 1981.


Triaxial testing of 150- by 300-mm concrete cylinders determined strengths and deformation characteristics, such as shear. This unique machine was designed by the Naval Ordnance Depot in the early 1940's.

*You are cordially invited
to attend the Open House sponsored by the
Bureau of Reclamation's Division of Research,
to be held on Thursday, December 3, 1981,
3 to 8 p.m., in Building 56,
Denver Federal Center.*



The Bartlett Dam model was constructed to study modifications to prevent damage to the spillway chute.

Hydraulic Models... Scale-sized Problem Solving

By Linda Amato Bard

As visitors step through the doors of Building 56 at the Denver Federal Center, childhood days of model-building come to mind. For in Building 56's hydraulic lab, you will find some eighteen working models of various Bureau of Reclamation dams. Actual scaled down versions of some of the large hydroelectric dams constructed throughout the West, built out of marine plywood, metal and glass.

Non-working "mini-models" of dams such as Hoover Dam in Nevada and Glen Canyon in Utah are also on display. The larger working models of Grand Coulee in Washington, Stewart Mountain in Arizona and even Daule-Peripa Dam in Ecuador are impressive as water pours over the spillways, down the miniature canals and back into the water recirculating system under the laboratory floor.

Linda Amato Bard is a writer-editor in the Public Affairs Center, Denver, Colorado.

Photography by Wayne Lambert, Engineering and Research Center, Denver, Colorado.

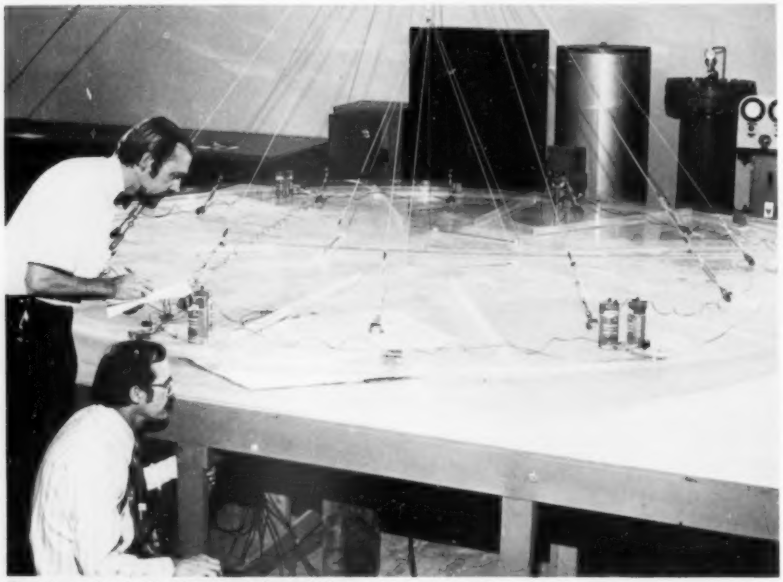
The models were used to evaluate the design of the dams and spillways, and to solve problems in modifying or repairing existing structures. Model studies help hydraulic engineers evaluate how well their design will work—before anything is built. Engineers can decide whether corrections or changes need to be made or that a theoretical design can be improved and more work at the drawing board is needed.

Not all dams or other structures built by the Bureau of Reclamation are model tested, however. When initial designs of a dam are begun designers and hydraulic engineers work together perfecting the design. If no problems arise during this stage or if there is nothing unusual involved in the design, a model is usually not necessary. Instead, the design is computer tested. However, if the structure has an unusual design or problems are foreseen, a model built to scale is constructed for testing.

Hoover Dam, constructed in 1935, was the greatest construction project the Bureau of Reclamation had undertaken since its beginning as the Reclamation Service in 1902. It was also the first dam model built by Reclamation engineers. At 726 feet this concrete arch gravity dam still holds the distinction of being the western hemisphere's highest concrete arch dam. Since Hoover Dam was the largest built up to that time, Reclamation designers needed help in perfecting the design. A group of engineers, carpenters and laborers brought the proposed design of Hoover Dam to life in a small laboratory in Fort Collins. That was in 1930 and, since that time, models of Stewart Mountain, Grand Coulee, Morrow Point and many others have been first constructed as models and tested in the Hydraulics Laboratory.

The longest model ever built by Reclamation engineers was a model of the Columbia River below Grand Coulee Dam. This model ran the entire width of the laboratory, about two city blocks. The highest model ever constructed in the labs was the Morrow Point Dam spillway. It reached nearly to the ceiling, about three stories high. Unfortunately because of the limited space in the laboratory these models had to be dismantled to make way for other model testing projects.

Today, as in earlier days, the Bureau of Reclamation research program is directed toward solving problems and developing new technologies associated with



The atmospheric simulator uses layered liquid to represent the atmosphere. A floating rotating lid generates wind across a plastic raised relief map to study the distribution of cloud seeding materials and to determine the best location for wind turbines.

water resource development and conservation, and use of water and related resources.

Hydraulics research is not limited to studying dams. One of the most impressive pieces of lab equipment is a low-ambient pressure (vacuum) chamber. This chamber is used to study cavities or holes that develop in concrete from water under low pressure. Another interesting study being conducted in the labs is a full-scale sectional model simulating a portion of the proposed McClusky Canal fish screen. The problem is that certain species of fish found in the Missouri River in North Dakota might be diverted into a canal system causing undesirable effects of sport fisheries downstream and interfering with waterfowl breeding grounds.

Reclamation researchers are continually developing new technology and more sophisticated mechanical equipment for water use and conservation, such as valves, hydraulic gates for dams and other structures, turbines and penstock pipe.

In 1980 the Hydraulic Laboratory, one of five research branches located in Building 56, celebrated its 50th Anniversary. And today, 51 years later, helping designers is still a major activity in the labs, along with solving problems associated with operation and maintenance of Reclamation's hydraulic works and river system control.

Tours of the laboratory are available and can be arranged by calling the Bureau of Reclamation at the Denver Federal Center.

The Bureau of Reclamation has grown with the times and needs of our Nation, and Reclamation engineers are continually exploring an ever-widening range of projects . . . from flood damage problems of 70-year-old Roosevelt Dam in Arizona, to bicycle-safe grate inlet designs for the Federal Highway Administration.

A scale model of Crystal Dam was used to study the water flow down the ski-jump bucket spillway dropping 220 feet to the river channel.

This model of Roosevelt Dam in Arizona was built to study flow conditions and to design erosion protection.

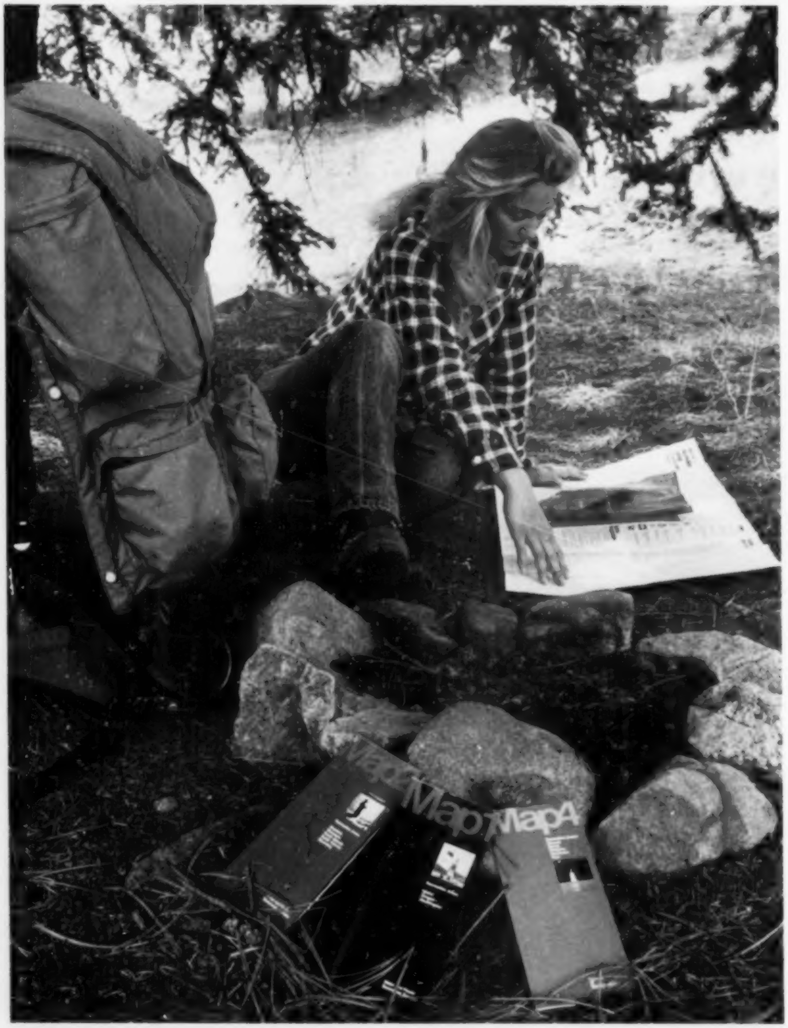
Recreation Maps Updated

The Bureau of Reclamation has recently revised and updated a set of four recreation map brochures. Each brochure features a road map showing interstate and major roads, larger towns and cities as well as the Reclamation recreation areas. There is also a "Facilities and Activities" section which informs the reader what they can expect to find at each area.

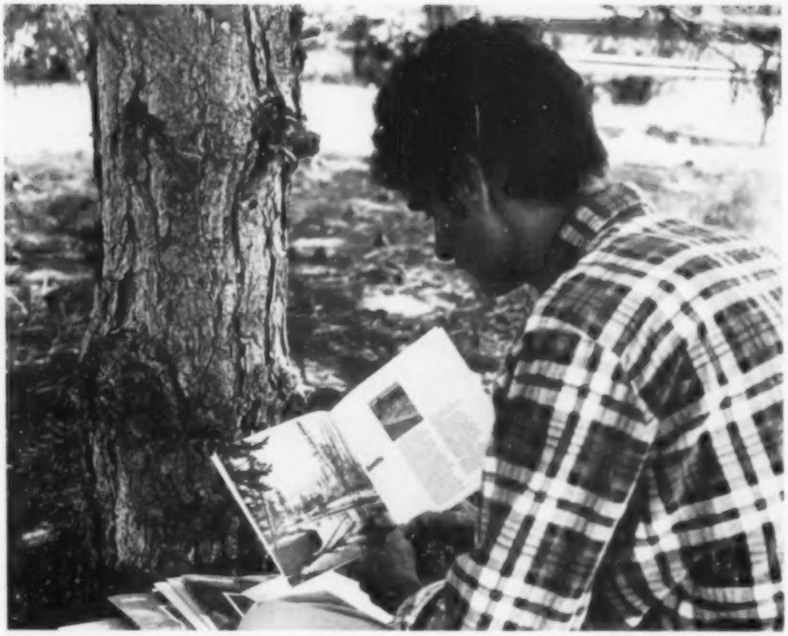
The meaning of safety markers are explained and a few safety tips are also included. A narrative for each area gives what special attractions are close by, written directions how to get to the area and where to write for more information.

Map One includes the States of Idaho, Washington and Oregon. Map Two covers Montana, North and South Dakota, Nebraska and Wyoming. Map Three features California, Nevada, Utah and Arizona. Map Four contains Colorado, Kansas, Oklahoma, Texas and New Mexico.

This set can also be obtained by writing to the Bureau of Reclamation, Attention: Code D-140, PO Box 25007, Denver Federal Center, Denver, Colorado 80225. They are free.



One For Each Western State



Photography by John R. Norquist, Engineering and Research Center, Denver, Colorado.

The Bureau of Reclamation has revised and updated a set of booklets on the 17 Western States. Each booklet includes a section on history, benefits, future development and a project summary.

The history section capsulizes the Reclamation background in each state; the benefits section summarizes the state's benefits from Reclamation projects and project water; the future section outlines what is being planned for Reclamation development within the state.

The project summary section includes a graphic map locating each project within the state, as well as a brief overview of each Reclamation project.

The booklets can be used as a handy quick reference to Reclamation development in each state. They can be requested singly or as a set from the Bureau of Reclamation, Attention: Code D-140, PO Box 25007, Denver Federal Center, Denver, Colorado 80225.

A Monumental Task Is Completed

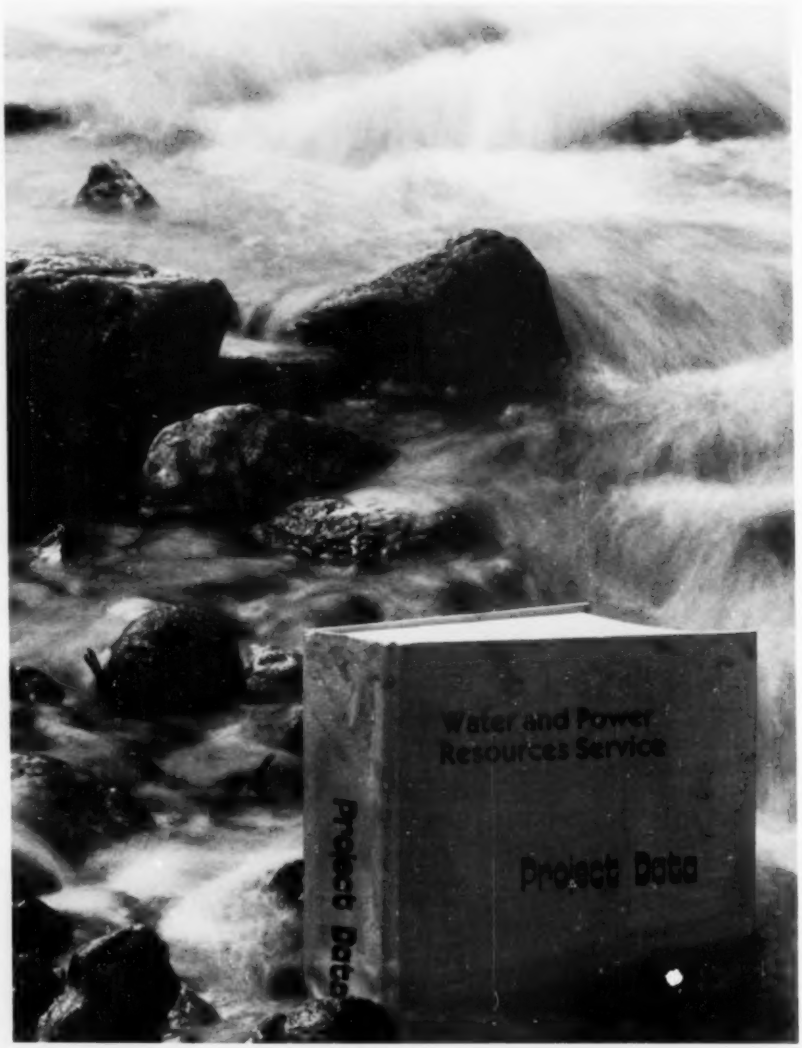
What is gold on the outside, black and white on the inside and weighs 12 pounds?

Give up? The new updated Project Data Book.

This voluminous 1,462-page publication contains a wealth of information on 195 multiple-purpose water resource projects built by the Bureau of Reclamation since 1902. Illustrated with maps, tables, photographs and graphs as well as narrative, the Project Data Book presents the histories and the summaries of all Reclamation projects: those completed and operating, those now under construction and those presently proposed.

The first edition of the Project Data Book was published in 1961, with a supplemental volume issued in 1966. The new updated Project Data Book took about four years to compile and publish.

The Project Data Book can be ordered from the Bureau of Reclamation, Attention: Code D-140, PO Box 25007, Denver Federal Center, Denver, Colorado 80225. The price for the manual is $21.00.



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